UCRL-WEB-201504

Mathematical Software Overview

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Preface

Scope: This Mathematical Software Overview introduces the approach to math software taken at LC, compares the chief math subroutine libraries available, and explains the lookup and support tools (including reference manuals) that help you use those libraries effectively. It also introduces a few important, commercial, interactive math tools.

Availability: Not all math tools and libraries are available on all machines. So the summary of each in this document gives specifics on where you can find them (and why). This chart shows overall availability by machine type:

	Platform/OS		
	IBM/AIX	Intel/Linux	Compaq/Tru64
Installed as compiled (object) code	LIBM	PMATH	PMATH
	ESSL		SLATEC
	PESSL	MKL	DXML
	FFTW (OCF)	FFTW (OCF)	FFTW (OCF)
	SPRNG	SPRNG	SPRNG
Downloadable from LINMath (you compile)	PMATH	PMATH	PMATH (newer)
	SLATEC	SLATEC	SLATEC (newer)
	MSSL	MSSL	MSSL

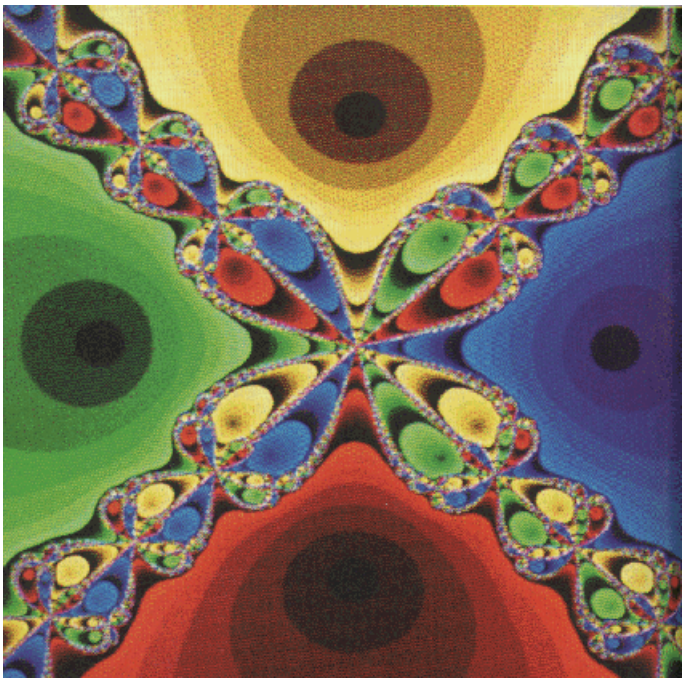
[NOTE: PMATH, SLATEC, and MSSL are all available from the LINMath (page 8) web site as source code, which you can then move to any machine and compile.]

Consultant: For help contact the LC customer service and support hotline at 925-422-4531 (open e-mail: lc-hotline@llnl.gov, secure e-mail: lc-hotline@pop.llnl.gov).

Printing: The print file for this document can be found at

OCF: http://www.llnl.gov/LCdocs/math/math.pdf
SCF: https://lc.llnl.gov/LCdocs/math/math_scf.pdf

Attractors for Newton's Method, f(z) = ((z**4)-1).



Introduction

The belief behind LC's approach to mathematical software support is that computational tasks required in a wide variety of applications share common, mathematically defined features, to which general purpose techniques can be applied. This results in a long-term overall cost savings, through software reuse and reduced duplication of effort.

This approach was long embodied in LC's very fruitful Mathematical Software Service (MSS, see the next section). It is still reflected in the surviving products of that former group, including local libraries (such as PMATH) and local math self-help tools for numerical mathematics (such as the LINMath (page 8) web site). This document surveys those libraries and tools, compares their features, and offers links to the current reference documentation for each one.

Former MSS Group

Until May, 1996, the focus of math support at LC was a separate Mathematical Software Support Service (MSS). This was a group of professional computational mathematicians whose duties included:

- installing and maintaining mathematical libraries and utilities on the primary LC systems, such as the CRAYs,
- providing mathematical software for users of systems not associated with the large LC machines, as a laboratory-wide service to the LLNL scientific computing infrastructure,
- consulting and advising on numerical methods and software, and
- providing a means for sharing the results of research on numerical algorithms (performed at LLNL or elsewhere) among the scientists and engineers at the laboratory.

Although the MSS has disbanded, its many useful products remain in play, especially on the DEC/COMPAQ machines at LC (and their sources are user-movable elsewhere). The former MSS consulting duties now fall to the central LC Hotline (page ?) staff. And this introductory document replaces the former MSS home page as the online focal point for basic math-support information.

Math Libraries Chart

The current mix of machines from several competing vendors at LC means that the traditional, locally developed mathematics libraries (such as the now-defunct MATHLIB) on which many codes once depended have been replaced by either new, portable versions (such as PMATH) or by commercial, vendor-specific libraries. This document introduces the remaining noncommercial libraries.

The chart below shows at a glance which math libraries reside on which LC machines:

	Platform/OS		
	IBM/AIX	Intel/Linux	Compaq/Tru64
Installed as compiled (object) code	LIBM(*)	PMATH	PMATH
	ESSL		SLATEC
	PESSL	MKL	DXML
	FFTW (OCF)	FFTW (OCF)	FFTW (OCF)
	SPRNG	SPRNG	SPRNG
Downloadable from LINMath (you compile)	PMATH	PMATH	PMATH (newer)
	SLATEC	SLATEC	SLATEC (newer)
	MSSL	MSSL	MSSL

[NOTE: PMATH, SLATEC, and MSSL are all available from the LINMath (page 8) web site as source code, which you can then move to any machine and compile.]

(*)Beginning in May, 2003, LC provides preinstalled on all IBM/AIX machines (open and secure) the Mathematical Acceleration Subsystem (MASS, or libmass.a), which offers "tuned alternatives" for many LIBM functions to help optimize codes. Vendor support is available at the (open only) web site:

http://techsupport.services.ibm.com/server/mass?fetch=home.html

NMG (Retired)

NMG (the "numerical mathematics guide") was an interactive utility that provided guidance for and access to the LC-supported math libraries. NMG helped users select appropriate math subroutines for specified computational tasks, and then let them retrieve documentation or (when nonproprietary) source code for the subroutines selected.

NMG retired from public service along with LC's secure CRAY J90 computers in March, 2000. However, most NMG functions live on in a different form as various levels in the LINMath (page 8) web site, described in the next section.

LINMath Web Site (Tool)

LINMath (Livermore Interactive Numerical Mathematics software access utility) is a customized world-wide web site that delivers advice on and descriptions of mathematical library subroutines, as well as the subroutine source files themselves. The LINMath web site uses the standard GAMS (URL: http://www.llnl.gov/LCdocs/gams) (Guide to Available Mathematical Software) hierarchical system for organizing math routines to structure its menu tree.

The LINMath web site offers most of the same math-help functions formerly provided by the now-defunct CRAY NMG utility, only in a different way (as hypertext). Also, LINMath provides the most recent, debugged versions of SLATEC and PMATH routines (*more* recent than the versions installed on some LC machines as compiled object code).

LINMath Features

To use the LINMath web site, execute any standard WWW browser (client) and request the open URL

`http://www-r.llnl.gov/sccd/linmath`

As the URL implies (www-r), the LINMath server automatically restricts access to only those clients running on machines within the LLNL domain(s). Currently, a comparable LINMath site is under construction at a web server within the LLNL secure network at the SCF URL

`http://www.scf.cln/sccd/linmath`

Users of the former NMG tool will recognize LINMath as a web-based version of NMG. Of course, LINMath relies on interactive hypertext links and other common web browser (client) features, rather than on commands typed in response to prompts, to navigate its structure and ultimately to deliver appropriate mathematical software. Partly for this reason, LINMath combines into a single menu tree the advice, menu, and fetch (download) features that were once available as separate NMG commands. LINMath covers the most up-to-date versions of the SLATEC, MSSL, and PMATH subroutine libraries directly, with indirect support for other, external math libraries.

LINMath Documentation

LINMath's basic instructions, access restrictions, and practical usage tips are all covered in the LINMath User Guide (URL: http://www.llnl.gov/LCdocs/nmg1). This manual also compares the top, middle, and bottom levels of the LINMath tree with the menu, advice, and fetch commands of the former NMG utility, respectively.

Because the LINMath site is divided among many separate files, you cannot display (or print) the entire GAMS classification scheme from the site itself. If a comprehensive and comparative overview of the entire GAMS scheme would help you with LINMath planning and subroutine decisions, consult the separate GAMS online document (URL: http://www.llnl.gov/LCdocs/gams). This document contains NIST's complete Guide to Available Mathematical Software.

You can easily display or print (with File/Print Frame) the full set of subject headings for any GAMS subject category using your WWW client. Or you can print the entire 28-page GAMS document for reference by getting its PostScript file from either the open or secure LC anonymous FTP server using the printing directions in the Documentation Guide (URL: http://www.llnl.gov/LCdocs/docguide) (or in the first section of the GAMS document).

Math Libraries

This section introduces the NONPROPRIETARY math subroutine libraries that LC provides and (passively) supports.

SLATEC Library

Background

SLATEC is an acronym for the Sandia, Los Alamos, Air Force Weapons Laboratory Technical Exchange Committee. Formed in 1974 to foster exchange among these three New Mexico laboratories, it has since been expanded to include LLNL (both LC and the former NERSC), ORNL, and NIST (the National Institute for Standards and Technology, formerly NBS). On occasion, ANL, NCAR, and other Government laboratories have also been involved in SLATEC activities.

The Common Mathematical Library (CML) developed by SLATEC is a portable Fortran 77 library of high-quality mathematical software. It includes the widely-known packages BSPLINE, EISPACK, FISHPACK, FNLIB, LINPACK, PCHIP, QUADPACK and much more. (It is very weak in statistical software.)

Routines from this library, being nonproprietary and portable, may be used on both the LC mainframes and the user's workstation. SLATEC has been installed as a precompiled binary library on all LC-supported COMPAQ (nonLinux) computers (open and secure). SLATEC is not available, however, on the IBM SP, but you can move source code that you get from LINMath. In fact, since the LINMath sources are more recent and more thoroughly debugged than the installed binaries, Tru64 and Linux users are also encouraged to prefer the LINMath version of all SLATEC routines.

Documentation

To help you use the SLATEC library effectively, LC provides five supporting manuals:

SLATEC1 — provides introductory information on the whole SLATEC library, including background on five of the software "packages" it contains, descriptions of the SLATEC error procedure, and advice for interpreting SLATEC's highly stylized explanatory prologues. SLATEC1 introduces the GAMS subject categories (URL: http://www.llnl.gov/LCdocs/gams) into which the SLATEC routines are grouped, and includes short descriptions of all routines (alphabetical within each subject category). Every category code is also a link (keyword) for retrieving the brief descriptions of the included routines, and every routine name links back to its category. SLATEC1 (with links) provides the only way to compare related routines by the tasks they perform, rather than just by name.

SLATEC2 — contains the calling sequence and usage details for each of the 225 subroutines from AAAAAA through D9UPAK, arranged alphabetically by name. Every subroutine name is also a link (keyword) for retrieving the corresponding description if you start at the index.

SLATEC3 contains the calling sequence and usage details for each of the 225 subroutines from DACOSH through DS2Y, arranged alphabetically by name. Every subroutine name is also a link (keyword) for retrieving the corresponding description if you start at the index.

SLATEC4 contains the calling sequence and usage details for each of the 226 subroutines from DSBMV through RD, arranged alphabetically by name. Every subroutine name is also a link (keyword) for retrieving the corresponding description if you start at the index. (NOTE: At LC, use service routines I1MACH and R1MACH (page 20) from MSSL (page 13) rather than from SLATEC for more accurate results.)

SLATEC5 contains the calling sequence and usage details for each of the 226 subroutines from REBAK through ZBIRY, arranged alphabetically by name. Every subroutine name is also a link (keyword) for retrieving the corresponding description if you start at the index.

Also, online documentation (comment prologs) for individual user-callable SLATEC routines is available through the open-network LINMath (page 8) web site.

PMATH Library

The PMATH mathematics subroutine library (libpmath.a) is a portable version of the CAL-coded part of the former MATHLIB library (libmath.a), with a few extra routines added, for a total of 68 routines. PMATH supplements but does not duplicate the SLATEC library.

Inspired by a user survey conducted in November, 1992, LC's former Mathematical Software Services group developed portable versions of the CAL-coded part of MATHLIB (formerly /usr/local/lib/libmath.a on the CRAYs). This machine-independent mathematics subroutine library they called PMATH (libpmath.a). While the original MATHLIB was only available on LC's CRAY Y-MP computers, PMATH is also available on LC's Compaq and Linux production computers (open and secure). It is not, however, available on the IBM SP, but you can move its source code from LINMath. In fact, since the LINMath sources are more recent and more thoroughly debugged than the installed binaries, Tru64 and Linux users are also encouraged to prefer the LINMath version of all PMATH routines.

Documentation for PMATH originally consisted of its design specification, an inventory of routines, and 68 separate SLATEC-style explanatory prologs. Now all this material has been organized into the 135-page PMATH Library Reference Manual (URL: http://www.llnl.gov/LCdocs/pmath), which is available online through LC's documentation servers (both open and secure). Early sections of this manual explain the design principles (including the name-choice principles) for the PMATH library and how they were implemented. Because of the close connection between MATHLIB and PMATH, the PMATH manual introduces the PMATH routines using their MATHLIB counterparts, and notes which MATHLIB routines were omitted from PMATH. A conversion chart between the MATHLIB and PMATH names is included. The PMATH rountines are also listed by functional group (statistical routines, ODE solvers, etc.) under their own names, with features of the newly added routines explained. The largest part of this manual by far is an alphabetical dictionary of PMATH routines and the descriptive prologs for each, including the calling sequence.

MSSL

MSSL (the Mathematical Software Service Library) is a collection of (Fortran) source code that is made available to LC users via the LINMath (page 8) web site. (Source code distributed from LINMath can then be moved to other machines if you wish.)

From its inception, MSSL was divided into three parts:

MSSL1 (Class 1): fully-supported routines.
Online documentation available. This class includes many of the Fortran routines in MATHLIB, as well as the best software resulting from CCSE (now CASC) research.

MSSL2 (Class 2): minimally-supported routines.
No online documentation. These routines are generally good quality, but probably originated outside LLNL.

MSSL3 (Class 3): unsupported routines.
No online documentation except for code comments delivered by LINMath. (page 8) Use these at your own risk (but many of these 300 routines are high-quality software). Use the MSSL3 service routines (page 20) instead of those in SLATEC for more accurate results.

As of September, 1994, LC no longer distinguishes between Class 1 and Class 2. These two classes have been merged and are referred to collectively as simply MSSL (about 100 routines). Once you identify a relevant MSSL routine using the LINMath web site help aids, you can (and must) retrieve any available documentation for it using LINMath as well. There is no separate MSSL reference manual. Online documentation is available for all user-callable MSSL routines via LINMath.

MATHLIB

The CRAY-based UNICOS library MATHLIB disappeared from LC along with the last Y-MP machine. See the PMATH (page 12) section above for information on the 68 MATHLIB routines whose portable versions are now provided through the PMATH library.

FFTW Library

FFTW is a free, nonproprietary C subroutine library for computing the Discrete Fourier Transform (DFT) in one or more dimensions, of both real and complex data, and of arbitrarily large input size. FFTW also efficiently handles multiple, strided transforms.

FFTW ("Fastest Fourier Transform in the West") was developed by Matteo Frigo and Steven G. Johnson at MIT. Version 2.1.3, November 1999, has been installed in these files on LC's open (only) AIX, Linux, and Tru64 machines:

```
/usr/local/lib/libfftw.la
/usr/local/lib/libfftw.a
/usr/local/lib/librfftw.la
/usr/local/lib/librfftw.a
/usr/local/include/fftw.h
/usr/local/include/rfftw.h
```

FFTW is released under the GNU general public license. It works on any platform with a C compiler, and it is also callable from Fortran. Its authors claim that it has benchmarked to be "superior to other publicly available FFT software."

Of special interest to LC users is FFTW's support for parallelization. FFTW offers parallelized code for SMP machines with POSIX threads (URL: http://www.llnl.gov/LCdocs/pthreads) (pthreads). And an MPI (URL: http://www.llnl.gov/LCdocs/mpi) version for distributed memory transforms is available as well.

For general information on the FFTW math library and background papers on its technical features, consult

```
http://www.fttw.org
```

For detailed online documentation in HTML (including a subroutine index), consult

```
http://www.fftw.org/doc
```

SPRNG Library

SPRNG is the Scalable Parallel Random Number Generators library, callable from both C and Fortran codes. About half of all supercomputer cycles now go to stochastic ("Monte Carlo methods") calculations, and the SPRNG library was developed specifically to support ASCI Monte Carlo computations under an ASCI Level 3 grant to Florida State University (a project originally sited at the University of Illinois).

As a shared, standard library for scalable pseudorandom number generation, SPRNG aims to:

- Provide an almost infinite supply of parallel pseudorandom number streams with good statistical properties within and among the streams,
- Allow pseudorandom number streams to be reproduced for computational verification, independent of processor load and number of processors used,
- Support creation of new unique pseudorandom number streams on a parallel machine without using interprocessor communication,
- Support serial and parallel code portability across platforms, and
- Provide several different types of pseudorandom numbers, all in a scalable manner.

SPRNG 2.0 includes all types of pseudorandom number generators in a single library (seldom needed), while SPRNG 1.0 (installed on LC machines) supplies each random number generator in its own library for efficiency.

SPRNG is preinstalled for public use on all LC ASCI IBM (AIX) computers (such as White and Blue), and on all LC production Compaq (Tru64) clusters (such as GPS, TC2K, and SC), as well as on open and secure Linux machines (such as ILX or Emperor).

In /usr/local/lib the name of each SPRNG library file reflects the kind of random number generator that it provides:

```
libcmrg.a    Combined Multiple Recursive Generator
liblcg.a     Linear Congruential Generator with Prime Addend
             (48-bit and 64-bit versions)
liblfg.a     Additive Lagged Fibonacci Generator
libmlfg.a    Multiplicative Lagged Fibonacci Generator
```

In /usr/local/include are three necessary support files:

```
sprng_f.h     Fortran header file
sprng.h       C header file
interface.h
```

The SPRNG library can be used in both serial and parallel code. If you use MPI with SPRNG, be sure to:

- Call MPI_Init *before* your first call to any SPRNG function, and
- Call MPI_Finalize *after* your last SPRNG function call.

The SPRNG support web site at

`http://sprng.cs.fsu.edu`

briefly describes the SPRNG project and also links to free, online (HTML) user documentation, including a brief Quick-Start Guide, a more thorough User Guide, and a complete Reference Manual that covers every SPRNG function. Specific technical questions about the library can also be sent directly to sprng@cs.fsu.edu.

MKL Library

MKL is Intel's threaded Math Kernel Library, a good source for BLAS and LAPACK routines in the Linux environment.

MKL is available *only* on LC machines with Intel chips, that is, only on the Intel Linux clusters (such as ILX, MCR, and ALC on the open network, or on Adelie or Emperor on the secure network). The relevant Linux system subdirectories are:

```
/usr/local/intel/mkl/lib/32   (the library files)
                     /include  (the include files)
                     /doc      (vendor documentation)
```

The Linux environment variable OMP_NUM_THREADS controls the number of threads spawned by the MKL routines (by default, MKL sets the number of threads equal to the number of processors where you run).

Interactive Math Tools

Two commercial interactive math programs, Mathematica and MATLAB, are available on some (but not all) LC production machines.

Mathematica

Mathematica, first created in 1988, is used for symbolic computation, as well as 2D and 3D graphics, and programming. Mathematica creates fully customizable, publication-quality, cross-platform electronic and printed documents with professional mathematical typesetting quality and generates web-ready documents. You can run Mathematica only on the Compaq/DEC machines (not the IBM machines) on both the open side and the secure side, which has the more recent 4.1 version.

Mathematica offers a choice of two interfaces: a text interface and a GUI interface. No initialization file is needed to use Mathematica. To start the text interface, type

```
math
```

There are a limited number of licenses on the Compaq/DEC machines. When you log into the program, if no license is available, you will receive a message indicating that the license limit has been reached or that no license was returned.

To use the GUI interface, log on using an X terminal or Xterm simulator and type

```
mathematica
```

Mathematica is located at /usr/local/mathematica.

To read more about Mathematica, consult Stephen Wolfram's *Mathematica, A System for Doing Mathematics by Computer*, which is considered the definitive source. There are also numerous web sites available. These sites may be of interest to you:

http://www.math.utep.edu/Mathematica/contents.html
http://saaz.lanl.gov/math/Math_Home.html
http://smc.vnet.net/mathbench.html
http://smc.vnet.net/MathGroup.html
http://www.wri.com
http://support.wolfram.com/
http://www.mathematica-journal.com/home/

MATLAB

MATLAB is an interactive matrix "laboratory" developed and distributed by MathWorks. It is used for tasks involving matrices, graphics, and general numerical computation. MATLAB is on the Compaq/DEC machines on both the open network and the secure network, and the number of licenses is limited. Starting in April, 2003, MATLAB also became available on LC's AIX (IBM) machines (but only 3 licenses on OCF, 8 licenses on SCF). If the licenses are being used, you will receive a warning telling you to "get a valid password." MATLAB is fairly straightforward to use. The underlying algorithms for MATLAB's built-in functions and supplied m-files are based on the standard libraries LINPACK and EISPACK. In addition, there are numerous extensions you can download from the Internet.

To run MATLAB, log on using an X terminal or Xterm simulator, and type

```
matlab
```

You can reach MATLAB's help documentation by typing helpwin at the prompt. A separate window opens and provides a list of help topics. Click the help topic you want to get more information. You can also type helpdesk or visit the MathWorks web site.

Helpful websites include

http://www.glue.umd.edu/~nsw/ench250/primer.htm
http://www4.ncsu.edu/unity/users/p/pfackler/www/MPRIMER.htm
http://www.mathworks.com/products/matlab/

Largest and Smallest Numbers

AVAILABLE NUMBERS:

The largest (and smallest) numbers that you can represent depend on the machine (chip set) that you are using, the compiler that you are using, and the data type (single precision, double precision, or integer). Follow these steps to discover the values most relevant to your needs:

(1) Select your

- target machine,
- target compiler (if several are available), and
- data type (single, double, integer).

(2) Log on to the target machine.

(3) Run Netscape (or another web browser) and supply the open or secure URL for LINMath, (page 8) LC's online math software source.

(a) On the LINMath home page, scroll down to the bottom, to the "GAMS Master Index."
(b) Select Category R (Service Routines).
(c) On the page that arrives next, select R1 (Machine-dependent constants).
(d) On the page that arrives next, select the MSSL3 library. WARNING: LINMath will also offer you routines in the SLATEC library, but avoid those. The SLATEC largest/smallest reporting routines have internal flaws that make them obsolete and unreliable on current LC machines.
(e) On the page that arrives next (MSSL3), select from these three routines those that meet your needs:

```
R1MACH   for single precision,
D1MACH   for double precision,
I1MACH   for integer values.
```

When commented source code (Fortran, with a C version imbedded in the comments) for each routine displays, save it to a file by using your browser's FILE menu.

(4) On your target machine using your target compiler, compile and run a test code invoking the MSSL3 routine that reports current local information on the data type of interest to you, where

```
R = R1MACH(1) reports the smallest positive magnitude,
R = R1MACH(2) reports the largest positive magnitude,
R = R1MACH(3) reports the smallest relative spacing,
R = R1MACH(4) reports the largest relative spacing,
R = R1MACH(5) reports the log10 of the arithmetic base
    (usually 2).

D = D1MACH(1) through (5)
    reports same as R except double precision.

I = I1MACH(9) reports the largest integer magnitude,
I = I1MACH(12) reports the smallest exponent (single precision),
I = I1MACH(13) reports the largest exponent (single precision),
I = I1MACH(15) reports the smallest exponent (double precision),
I = I1MACH(16) reports the largest exponent (double precision).
```

```
[other integer values can be reported as well]
```

AVAILABLE PRECISION:

You may be more interested in the effect of various "precision" choices on how your calculations are carried out than on largest or smallest represented values per se. In that case, consult a subset of the OCF LC ASCI support web pages to see the current local information on these precision topics:

- The *range* of binary, hexadecimal, character, and integer constants locally supported: http://www.llnl.gov/icc/lc/asci/fpe/fpe.source.html (URL: http://www.llnl.gov/icc/lc/asci/fpe/fpe.source.html)
- The allowed *byte sizes* for integer or real statements: http://www.llnl.gov/icc/lc/asci/fpe/fpe.statements.html (URL: http://www.llnl.gov/icc/lc/asci/fpe/fpe.statements.html)
- The specific *effects* of choosing double precision or double complex data types: http://www.llnl.gov/icc/lc/asci/fpe/double.options.html (URL: http://www.llnl.gov/icc/lc/asci/fpe/double.options.html)

Disclaimer

Keyword Index

To see an alphabetical list of keywords for this document, consult the next section (page 24).

Keyword	Description
entire	This entire document.
title	The name of this document.
scope	Topics covered in this document.
availability	Where these programs run.
who	Who to contact for assistance.
introduction	Role and goals of this document.
math-support-group	Former MSS group role.
math-chart	Chart of math libraries.
nmg	Numerical mathematics guide (retired).
linmath	Numerical math web site (tool).
linmath-features	LINMath features summarized.
linmath-documentation	LINMath and GAMS manuals introduced.
math-libraries	Nonproprietary LC libraries.
slatec	SLATEC library overview.
slatec-background	History, role of SLATEC.
slatec-documentation	SLATEC manuals introduced.
pmath	PMATH library overview.
mssl	MSSL library overview.
mathlib	MATHLIB library (replaced/defunct).
fftw	FFTW library overview.
sprng	SPRNG library overview.
mkl	MKL library overview.
math-tools	Commercial interactive math tools.
mathematica	Commercial symbolic math tool.
matlab	Commercial numerical math tool.
largest-numbers	Finding each machine's largest numbers.
smallest-numbers	Finding each machine's smallest numbers.
index	The structural index of keywords.
a	The alphabetical index of keywords.
date	The latest changes to this document.
revisions	The complete revision history.

Alphabetical List of Keywords

Keyword	Description
a	The alphabetical index of keywords.
availability	Where these programs run.
date	The latest changes to this document.
entire	This entire document.
fftw	FFTW library overview.
index	The structural index of keywords.
introduction	Role and goals of this document.
largest-numbers	Finding each machine's largest numbers.
linmath	Numerical math web site (tool).
linmath-features	LINMath features summarized.
linmath-documentation	LINMath and GAMS manuals introduced.
math-chart	Chart of math libraries.
math-libraries	Nonproprietary LC libraries.
math-support-group	Former MSS group role.
math-tools	Commercial interactive math tools.
mathematica	Commercial symbolic math tool.
mathlib	MATHLIB library (replaced/defunct).
matlab	Commercial numerical math tool.
mkl	MKL library overview.
mssl	MSSL library overview.
nmg	Numerical mathematics guide (tool).
pmath	PMATH library overview.
revisions	The complete revision history.
scope	Topics covered in this document.
slatec	SLATEC library overview.
slatec-background	History, role of SLATEC.
slatec-documentation	SLATEC manuals introduced.
smallest-numbers	Finding each machine's smallest numbers.
sprng	SPRNG library overview.
title	The name of this document.
who	Who to contact for assistance.

Date and Revisions

Revision Date	Keyword Affected	Description of Change
14Jan04	slatec	Former SLATEC_TOC deleted, unavailable.
17Jun03	mkl	Linux MKL library now available.
	index	New keyword for new section.
	math-chart	MASS (libmass.a) now on AIX.
	matlab	MATLAB now also on AIX.
03Dec02	availability	PMATH, SPRNG now on Linux.
	math-chart	PMATH, SPRNG now on Linux.
	pmath	Now on LC Linux machines.
	sprng	Now on LC Linux machines.
10Jun02	mssl	Better service routines noted.
	sprng	New math library added.
	largest-numbers	Finding largest, smallest numbers added.
	index	New keywords for new sections.
14Jan02	math-chart	Availability table revised.
	fftw	New math library added.
	linmath	LINMath has most recent sources.
	index	New keyword for new section.
20Mar01	math-tools	New section on interactive tools.
	index	New keywords for new section.
22Mar00	entire	CRAYs retired, all CRAY and NMG references suitably revised.
17Aug99	linmath	New URL, SCF version added.
	mathlib	Replaced by PMATH, details deleted.
	entire	All MATHLIB comments revised, keywords deleted.
23Jul98	linmath	LINMath web site added, role noted throughout the text.
12Aug97	entire	First edition of this document.

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